Pectinates Improve Frozen Fruit

Trials show that they reduce drainage of juice upon thawing, improve appearance of fruit and effect other advantages

By R. E. BUCK,* G. L. BAKER† and H. H. MOTTERN*

THROUGH the use of pectinates, it is possible to reduce the amount of juice which drains, upon thawing, from frozen strawberries, cherries, raspberries and peaches. And not only is this important advantage realized, but the appearance of the fruit is improved. Further, the presence of pectinate in the fruit makes possible the direct preparation of jellied products for desserts and other purposes.

These discoveries were made in preliminary trials during the summer of 1942, when several pectinate and pectin preparations were compared in the freezing of the products mentioned. These studies also indicated that pectinates prepared by either acid or enzyme demethylation are equally effective.

Purpose of Investigation

The most common treatment given fruits is the addition of sugar or sugar sirup before freezing. The addition of dry sugar draws the juice from the fruit and thus forms a sirup, which covers the fruit and protects it to some extent from the air and also slows down enzyme action. One disadvantage, however, is that in some cases the juice drawn from the fruit amounts to 40 to 50 percent of the initial weight of the fruit.

At the beginning of the investigation, it was thought that the pectinates might form a gel on the surface of the fruit and thus reduce the drainage of juice. This was found to be the case. It has been possible to evaluate the different pectinates from the standpoint of their use in freezing fruits by measuring the amount of drained juice. In addition, these pectinates should be of use in the preparation of desserts, jams, preserves, purées, fruit ices and ice cream toppings from the frozen product.

The results reported here are obviously of a preliminary nature. Before the feasibility of the use of pectinates in freezing fruits can be determined, further study will have to be given to such matters as cost, method of using and improvement of the product.

Experimental Procedure

Experimental frozen packs of strawberries, red cherries, raspberries and peaches were prepared. The strawberries were hulled, washed and sliced before packing. The cherries were washed and pitted, and the raspberries were washed. The peaches were halved, pitted, steamed for 70 seconds, peeled and sliced. In all the experiments fruit of about the same degree of maturity was used.

After the fruit was prepared, it was mixed with sugar and pectinate in varying proportions. A dry-sugar pack was used in most of the experiments. In all cases, the pectinate was first mixed with the sugar, and this combination was then sprinkled over and mixed with the prepared fruit. The fruit-sugar-pectinate preparations were packed in containers and placed in the freezer at a temperature of approximately 0 deg. F. (−18 deg. C.). The containers used were 4- and 8-oz. round, wide-mouth, screw-cap glass jars and 8-oz. waxed, cardboard cups which were paraffine sealed.

The samples were held in the freezer at 0 deg. F. (−18 deg. C.) and examined within 3 to 4 days after freezing and again after a storage period of 4 to 6 months. For examination, the packages were opened and allowed to stand until the contents reached room temperature (approximately 4 to 5 hours).

The samples were then turned into a 4-in., hemispherical, 12-mesh sieve and allowed to drain for 10 minutes. The weight of drained juice was then obtained, and the soluble solids content (refractometer) and viscosity of the juice were determined. The samples were then examined for color, gel formation and general appearance.

A number of pectinates differing in methoxyl content and method of preparation were used. The properties of some of them are given in Table I. These are the pectinates used for the preparation of the curves in the chart, which represent the general results obtained after a 4- to 6-month storage period.

The methoxyl content indicates the degree of demethylation. The methoxyl content of pectin obtained from apples or citrus fruits is about 10 percent. Gel power is arbitrarily defined as the weight of water gelled to a strength of 50 cm. of water pressure on the Delaware jelly tester by one unit weight of pectinate at optimum calcium concentration and pH of 2.9 to 3.5 in the presence of 35 percent of sugar in the final gel (1). The optimum calcium concentration is the ratio of calcium to pectinate that gives the highest gel strength. Too much calcium causes a precipitation of the pectinate, with a resulting decrease in gel strength.

* Eastern Regional Research Laboratory, Philadelphia, Pa.; Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

† Delaware Agricultural Experiment Station, Newark, Del.

TABLE I—Properties of Pectinates Used and Quantity Required for 50 Percent Reduction in Drainage of Juice.

Sample No.	Method of hydrolysis	Methoxyl (percent)	Calcium, optimum	Gel power	Pectinate required for 50 percent reduction in drainage of juice: Strawberries (percent)	Cherries (percent)	Raspberries (percent)	Peaches (percent)
H-52	not demethylated	10.00	....	232*	....	**	1.00	.....
H-54	acid	7.78	.100	180	0.60	**	0.50	1.10+
H-55	acid	6.55	.035	95	....	..	0.75	2.00+
H-52D	acid	6.10	.070	200	0.42	..	....	.....
H-56	acid	5.80	.030	100	....	..	1.28	2.00
H-59	acid	5.50	.030	100	....	..	....	2.00+
E-34	acid	4.31	.030	139	1.0+	..	....	.....
H-50A	enzyme	4.98	.018	83	....	..	....	1.00

*Jelly grade. **Cherries, fruit-sugar ratio = 4:1 — 0.97% 5:1 — 0.75% 6:1 — 0.80%

Results

The most outstanding effect of the addition of pectinate to fruit before freezing is the reduction of the amount of juice draining from the thawed fruit. The pectinate combines with the calcium of the fruit, forming a gel on the surface. Although the juice may be withdrawn from the fruit, some is held in the form of a gel and does not drain off or separate from the fruit on thawing. As the concentration of pectinate is increased, the gel formation increases, resulting in a smaller amount of juice draining from the fruit. Thus the drained-weight determination furnishes a means of evaluating the different pectinates.

In addition to reducing the amount of drained juice, the pectinate improved the general appearance of the thawed fruit. There was less darkening and a more natural color in the fruit. The gel formation on the surface gave the fruit a gloss, which improved its general appearance. In Table I are shown the quantities of the different pectinates required to reduce the quantity of drained juice by 50 percent. This 50 percent reduction was accompanied by the most desirable amount of gel formation. Increased quantities of pectinate further reduced the amount of drained juice, with the formation of excessive quantities of gel in the form of rather solid clumps. This detracted from the appearance of the fruit. While the figures cannot be considered absolute because of the fairly large experimental error, they indicate the relative value of the different pectinates.

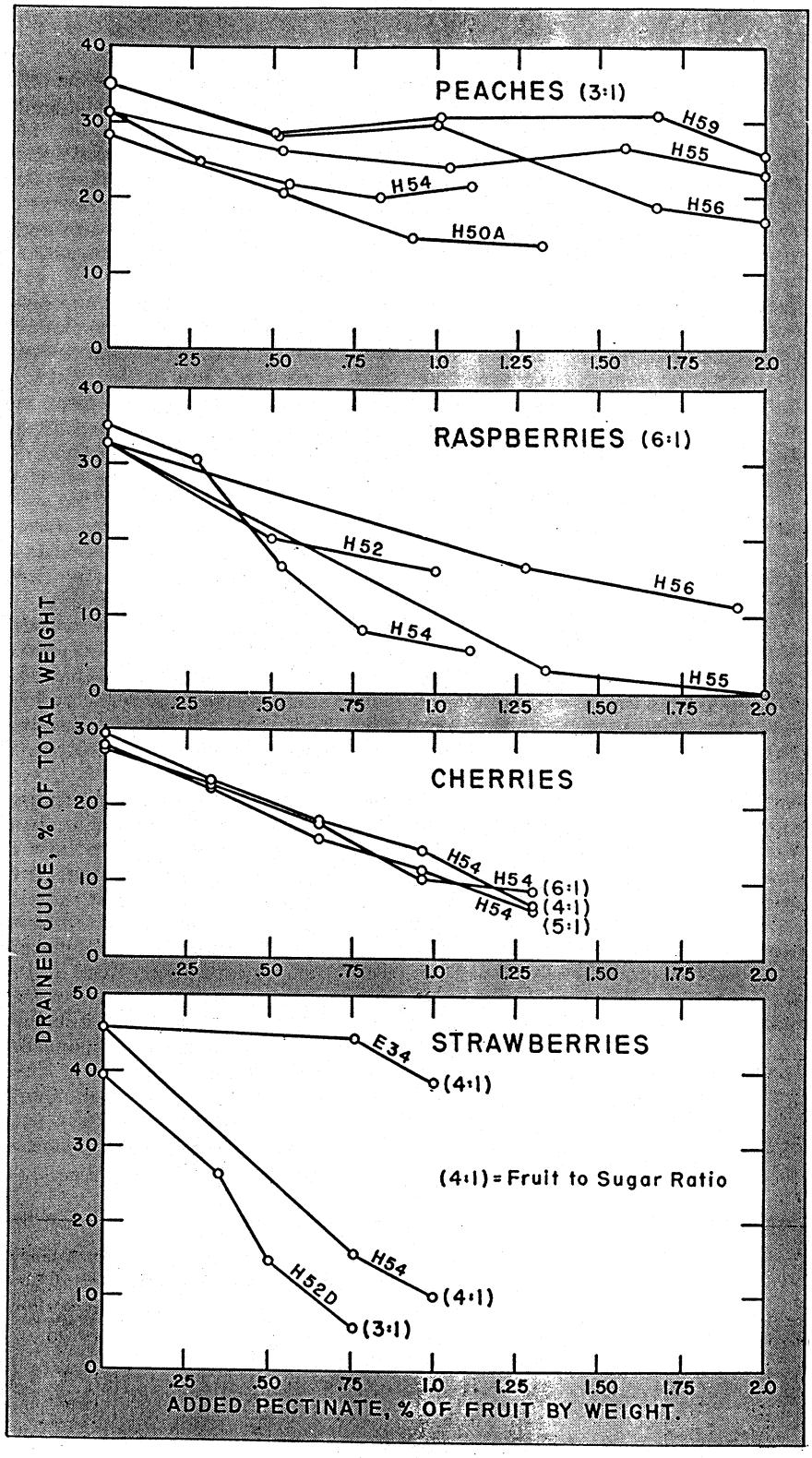
The results for the samples examined immediately after freezing and those examined after the longer storage period were in fairly close agreement for all the fruits except peaches. There was a more marked reduction in the quantity of drained juice in the samples of peaches examined immediately after freezing.

Strawberries

The results of freezing experiments on sliced strawberries of the Dorset variety are shown in the chart. The curves show that the addition of 1 percent of two pectinates used (H-54 and H-52D) decreased the quantity of drained juice from 40 percent or more to 10 percent or less. All the pectinates gave satisfactory results with the exception of E-34, which did not give a product much superior to the controls. Higher concentrations of this pectinate might have had a more pronounced effect. The gel power and calcium optimum for this sample were lower than for the other samples. Sample H-52D, which had a higher gel power than the others, was the most effective.

Cherries

Pectinate H-54 was used for all the tests on Early Richmond cherries. The curves show that the addition of the pectinate reduced the amount of drained juice from about 30 percent to less than 10 percent. It also improved the appearance of the fruit. There was less darkening, and the cherries had more nearly the appearance and texture of the fresh fruit. The results indicate that the optimum concentration of pectinate is about 0.8 percent, a larger proportion of pectinate causing the formation of too much gel,



Effect of different pectinates in reducing drained juice from four fruits after storage of 4 to 6 months.

which detracts from the appearance of the fruit.

Raspberries

Red raspberries (Latham variety) were used for the freezing test. The curves show that the presence of the pectinate reduced the amount of drained juice of two (H-54 and H-55) of the four samples used about 30 percent to 5 percent or less, with a corresponding improvement in the appearance of the thawed fruit. One sample of an undemethylated pectin, H-52, was used and found to be not quite so effective as a demethylated product, H-54, with a high gel power. About one-third more of the undemethylated pectin than of the demethylated product was required to give the same reduction in the amount of drained juice. More of pectinate samples H-55 and H-56, which have low gel powers and low calcium optima, was required to give the same results. These pectinates were effective, however, if large enough quantities were used.

Peaches

Some typical results of the addition of pectinate to peaches are given in the chart. Examination of the samples immediately after freezing showed that the pectinate was effective in reducing the amount of drained juice, although not so effective as with the other fruits. After a 4-month storage period, however, the results were not so marked, as shown in the curves. Except for pectinate samples H-56 and H-50A, the reduction was small, as compared with that of the other fruits. The pectinate, however, gave the fruit a better appearance than that of the controls. Several varieties of peaches were frozen, including Golden Jubilee, Hale Haven, Elberta and Hale, with no apparent difference in the action of the pectinate.

Up to this point in the investigation, it was assumed that the gel power of the pectinate was the determining factor in its action. As shown in the chart, however, pectinate H-50A, which has a very low gel power, was the most effective of the samples used. This sample was an enzyme-demethylated product, whereas all the other samples used up to this point were acid-demethylated. Consequently an experiment was set up using 25 preparations of pectinates of varying properties in order to determine the factors involved in reducing the amount of drained juice. No correlation could be found between the amount of drained juice and the different characteristics and properties of the pectinates, such as methoxyl content, calcium optimum and gel power, or the method of demethylation. Particle size and rate of solution may be factors of as much importance as the others listed. Most of the pectinates worked fairly well in reducing the amount of drained juice, regardless of the properties of the individual pectinates. From this it appears that an actual test is the only sure method of determining the effectiveness of a given pectinate for freezing use.

Commercial Packs of Frozen Peaches

Experimental packs of Elberta peaches with added pectinate were frozen in two commercial freezing plants, one in Virginia and the other in New York State. A sugar sirup was used in place of the dry-sugar pack used in the laboratory experiments. The samples of pectinate were dissolved in the sugar sirup, and the fruit was then packed according to the usual procedure followed at these plants. The results obtained were similar to those obtained in the laboratory. The pectinate reduced the amount of drained juice and also improved the appearance of the fruit. Appreciable browning of some of the peaches did not occur until several hours after thawing. The control samples browned rather rapidly. Predipping the peaches in a solution of calcium chloride and citric acid increased the formation of a gel on the surface of the fruit.

Both enzyme- and acid-demethylated pectinates were used in these commercial trials and also a high-ester, undemethylated pectin. The latter was not so satisfactory as the low-ester pectinates. There was not a great deal of difference in the action of the acid- and enzyme-demethylated products, although in one set of samples the action of the acid-demethylated preparation was slightly more advantageous.

One difficulty encountered in the use of the sugar sirup was that the pectinate made the sirup so viscous it was hard to handle. This difficulty can probably be overcome by adjusting the concentration of the pectinate or by raising the pH value of the sirup slightly, which will decrease the viscosity. More work must be done on this point to determine the amount of pectinate that will produce the desired results and yet leave the sirup in such a condition that it can be easily handled.

In one set of samples in the commercial plant tests a dry-sugar pack was used. The results were not so satisfactory as those obtained in the laboratory, inasmuch as there was no appreciable reduction in the amount of drained juice. There was an increase in the viscosity of the juice but not sufficient to reduce the amount of drainage. Thirty-pound samples of peaches were used for this pack, and probably the pectinate was not completely dispersed through the fruit with the result that there was little gel formation. There is no reason to believe, however, that the pectinate would not act in the same manner as in the smaller packages if it had been completely dispersed on the surface of the fruit.

Predipping in Calcium Chloride Solutions

Since calcium is essential for the formation of the pectinate gels, it was thought that the addition of calcium might increase the action of the pectinate. Experiments shows that predipping the fruit in a solution containing 0.2 percent calcium chloride before packing definitely aided the action of the pectinate. This pretreatment reduced the amount of drained juice 8 to 10 percent more than the pectinate alone. Calcium chloride mixed with the pectinate before addition to the fruit decreased the action of the pectinate, probably because of the difficulty of thoroughly dispersing the small amounts of this chemical through the fruit-sugar-pectinate mixture. The local concentrations of calcium served only to precipitate some of the pectinate and thus reduce its effect.

Also a predip of the peaches in a 2 percent solution of citric acid lowered the pH value sufficiently to increase the effectiveness of the pectinate. This is probably because the peaches were not quite so acid as the other fruits used, and the acid produced a more favorable pH for the gelling of the pectinate. The failure of pectinate to improve Elberta peaches, noted by Baker (2), might have been due to an unfavorable acidity.

Effect of Added Pectase

It was thought that the addition of the enzyme pectase to the fruit before freezing might act on the natural fruit pectin and convert it to pectinic acid, which would have the same effect as added pectinate. Accordingly, samples of all the fruits used were frozen with an eggplant-pectase preparation added to the sugar. The desired effect was not obtained; there was little reduction in the amount of drained juice and no noticeable improvement in the appearance of the fruit. There was no gel formation, although there was a slight increase in the viscosity of the drained juice. Probably the pH value of the

fruit was unfavorable for pectase action.

Low-Sugar Jellied Products from Frozen Fruits

With these low-ester pectinates, which form gels at any desired sugar concentration, it should be possible to form jellied products directly from the frozen fruit. Consequently, after the drained weight determinations had been made, in some of the samples the drained juice was recombined with the fruit, heated to boiling, and then poured into jars and allowed to cool. Spreads of the desired consistency were obtained.

Because of the short heating period necessary to obtain the desired consistency, there was less loss of the aromatic constituents from the fruit, and the products had a full-fruit flavor not ordinarily found in these products. Also because of the lower sugar requirements necessary to form a gel, the excessive sweetness found in a 65-percent sugar product did not mask the fruit flavor.

The product obtained with the red, sour cherries was a gel containing the whole fruit, which would be excellent for dessert purposes. The product had the fine, full flavor of fresh cherries, and the texture of the fruit was similar to that of fresh cherries. The product containing 20 percent added sugar had about the right sweetness for dessert purposes. A concentration of pectinate of about 1 percent was necessary to give a satisfactory gel for this purpose.

Jellied products, both clear and pulpy, were prepared from the frozen raspberries containing the added pectinate. Further sugar was added to these preparations to give a total sugar content of 35 percent. The products had the natural fruit flavor because it was not necessary to boil them for an excessively long time to get the desired consistency. Again a concentration of 1 percent pectinate was necessary to produce the desired consistency. Too high a concentration of pectinate yields a product which has a "pasty" or "grainy" texture.

The preliminary results discussed above indicate that the gel power of the pectinate used is an important factor in preparing jellied products from the frozen fruit. A lower concentration of a pectinate with a high gel power may be used to obtain the desired consistency.

Of the three methods—alkali, acid and enzyme—proposed for producing pectinates, the last two have been under investigation in the Eastern Regional Research Laboratory. Early in the investigation it became evident that the properties of the pectinates produced by the two methods did not depend entirely on the amount of residual methyl ester but that other effects on the pectin molecule were involved. In studying methods of preparing these substances it was obvious that various criteria must be applied for their evaluation, among them being methyl ester content, viscosity, optimal calcium concentration for gel formation of pH to gel formation, molecular weight and application to a particular use. The use of pectinates in the freezing of fruits to reduce the amount of drained juice on thawing was suggested by Baker.

Interest in low-ester pectinates is increasing, as evidenced by the number of patents and other publications which have appeared in recent years (3,4,5,6,7). As the properties of low-ester pectins become better known, new uses will be found for which they are particularly adapted. Very little work has been reported on the use of pectic substances in the freezing preservation of fruits. Cowgill (3) was granted a patent in 1938 on the use of a "non-acid pectin" dispersed through the fruit, with or without sugar, for the purpose of reducing the amount of juice formed during the period of preservation. Baker (2) has shown that the addition of low-ester pectinates to strawberries before freezing resulted in an improved product. As a rule, he found that pectinates with a low-ester content gave better results than those with a high-ester content. With one variety of peaches (Elberta), however, the reverse was true. Tressler (8) has suggested the use of commercial pectin in the preparation of frozen-fruit purees for the manufacture of marble-type ice cream. Low-ester pectinates would seem to be suitable for this use, as gels could be formed of the same sugar content as the ice cream.

Conclusions and Summary

Most of the pectinate samples used were effective in reducing the amount of juice draining from fruit on thawing and in improving the appearance of the fruit. The characteristics of the pectinates did not seem to exert a great deal of influence on their action. Different samples of pectinates covering a wide range in ester content worked equally well, whether acid- or enzyme-demethylated, of high or low gel power, or of high or low calcium optimum. No correlation could be found between these properties and the action of the pectinate on the frozen fruit; hence it is impossible to predict the action of a given pectinate on frozen fruit without an actual trial. A pectinate which gives poor results for another purpose may be satisfactory as an agent in the freezing of fruits.

A reduction in the amount of juice lost on thawing is a definite advantage, especially in the baking trade, where the fruit is put up in large containers and the juice cannot be used for baking purposes.

In addition, the presence of the pectinate in the fruit makes possible the direct preparation of jellied products for desserts and for other purposes. The short heating period required gives these jellied products a better flavor than that of the ordinary pectin jelly products.

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